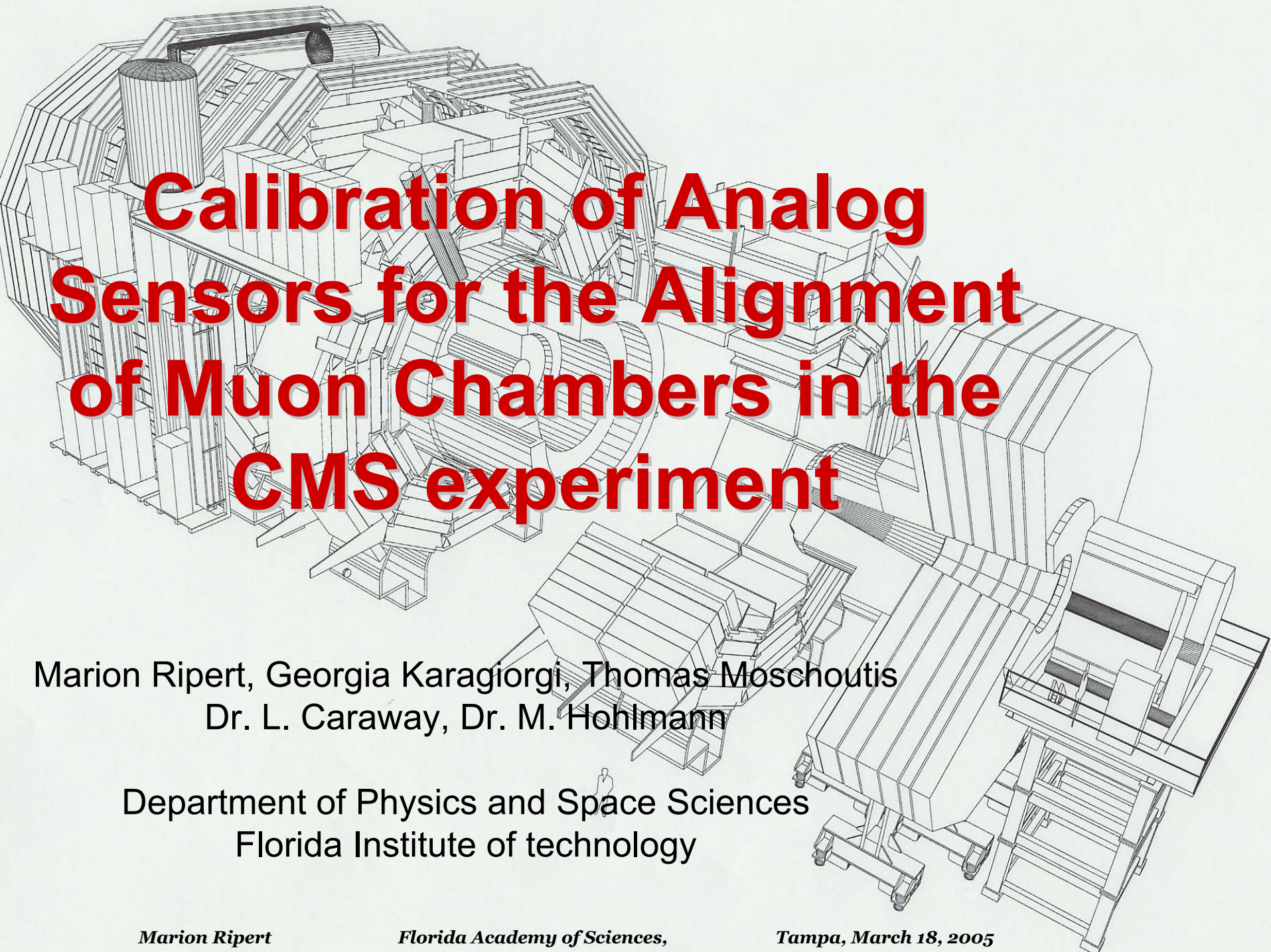

Calibration of Analog Sensors for the Alignment of Muon Chambers in the CMS experiment

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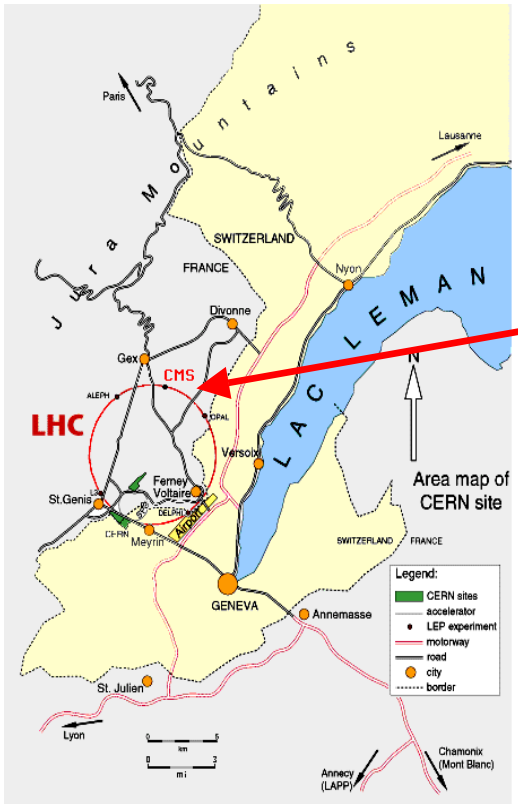
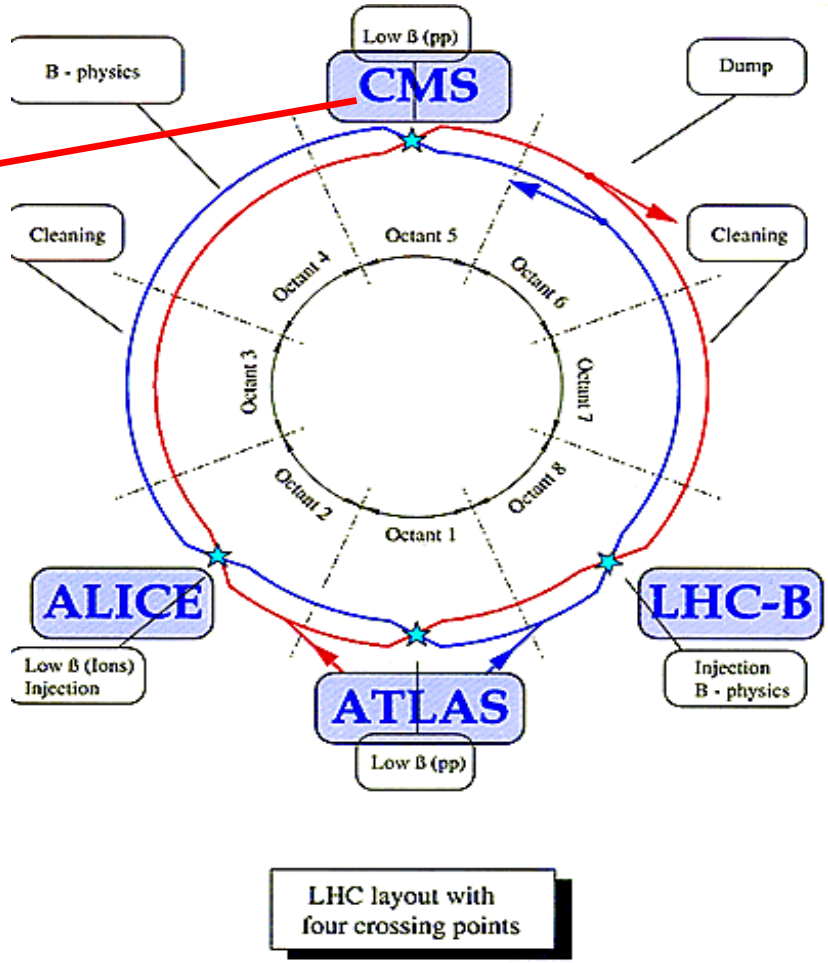
Large Hadron Collider

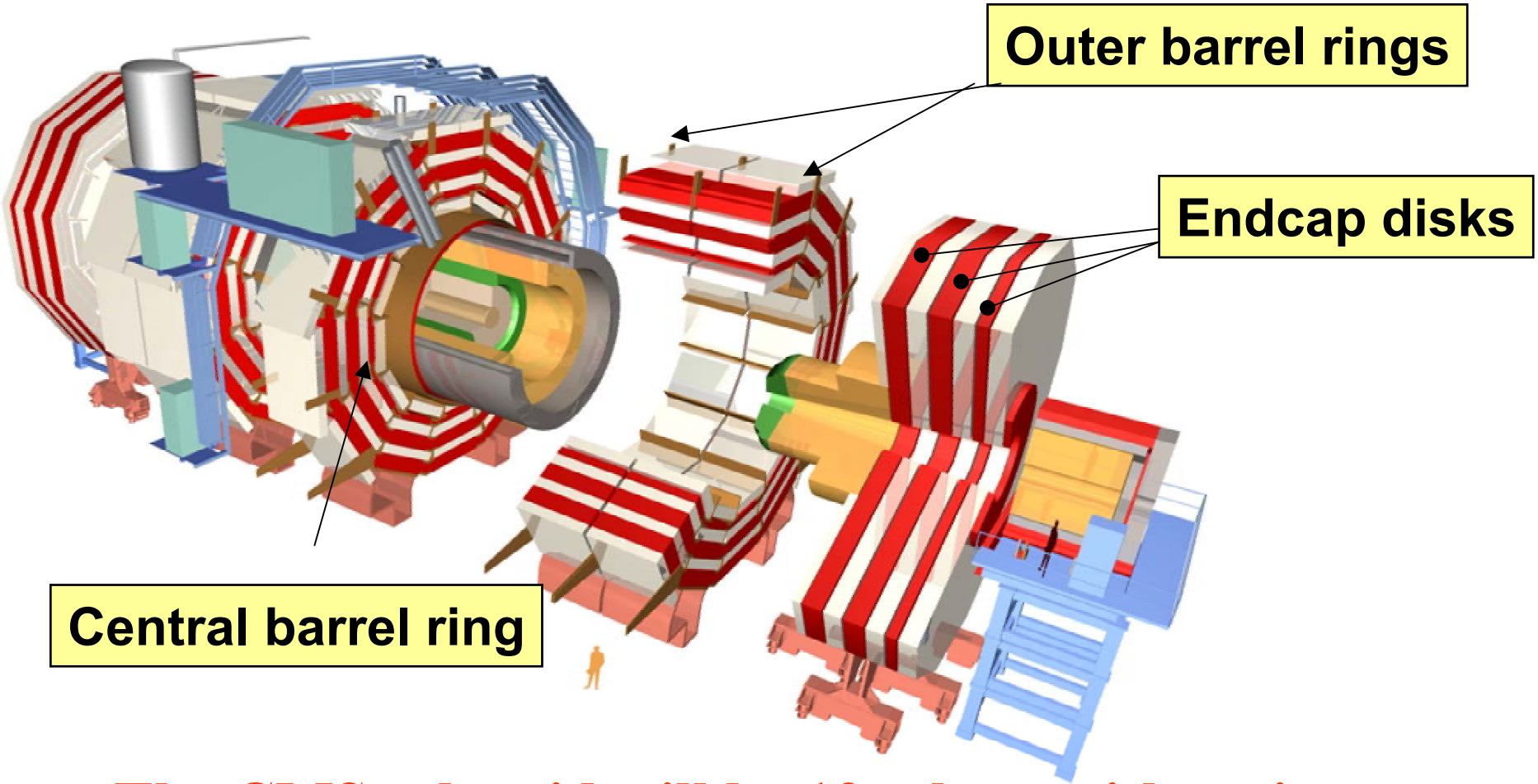




LHC layout with four crossing points

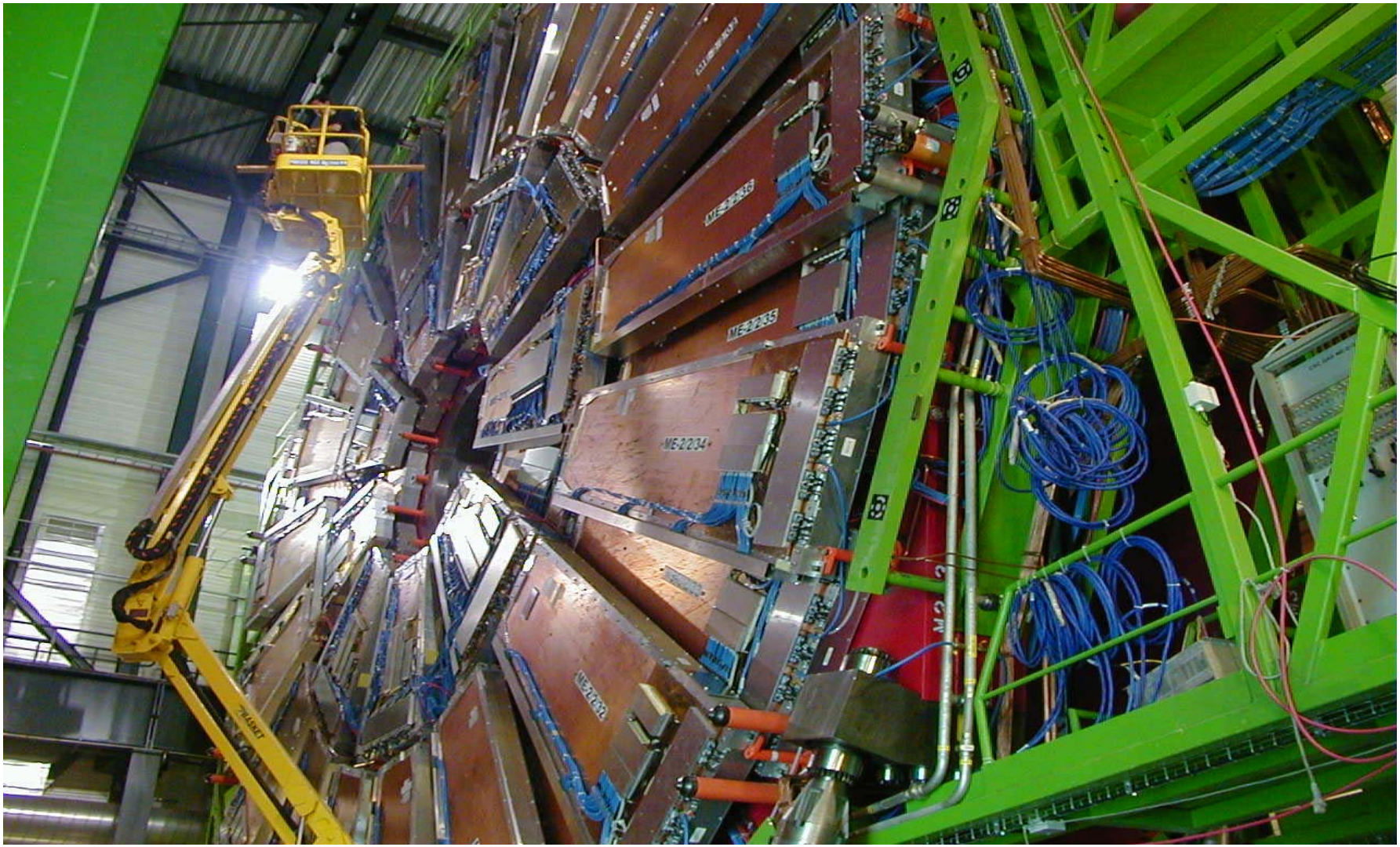
- pp machine (mainly) $\sqrt{s} = 14\ \text{TeV}$
  7 Times higher than energy in the Tevatron at Fermilab.
- Bunches of protons collide in CMS **every 25 ns**

The Muon Detector

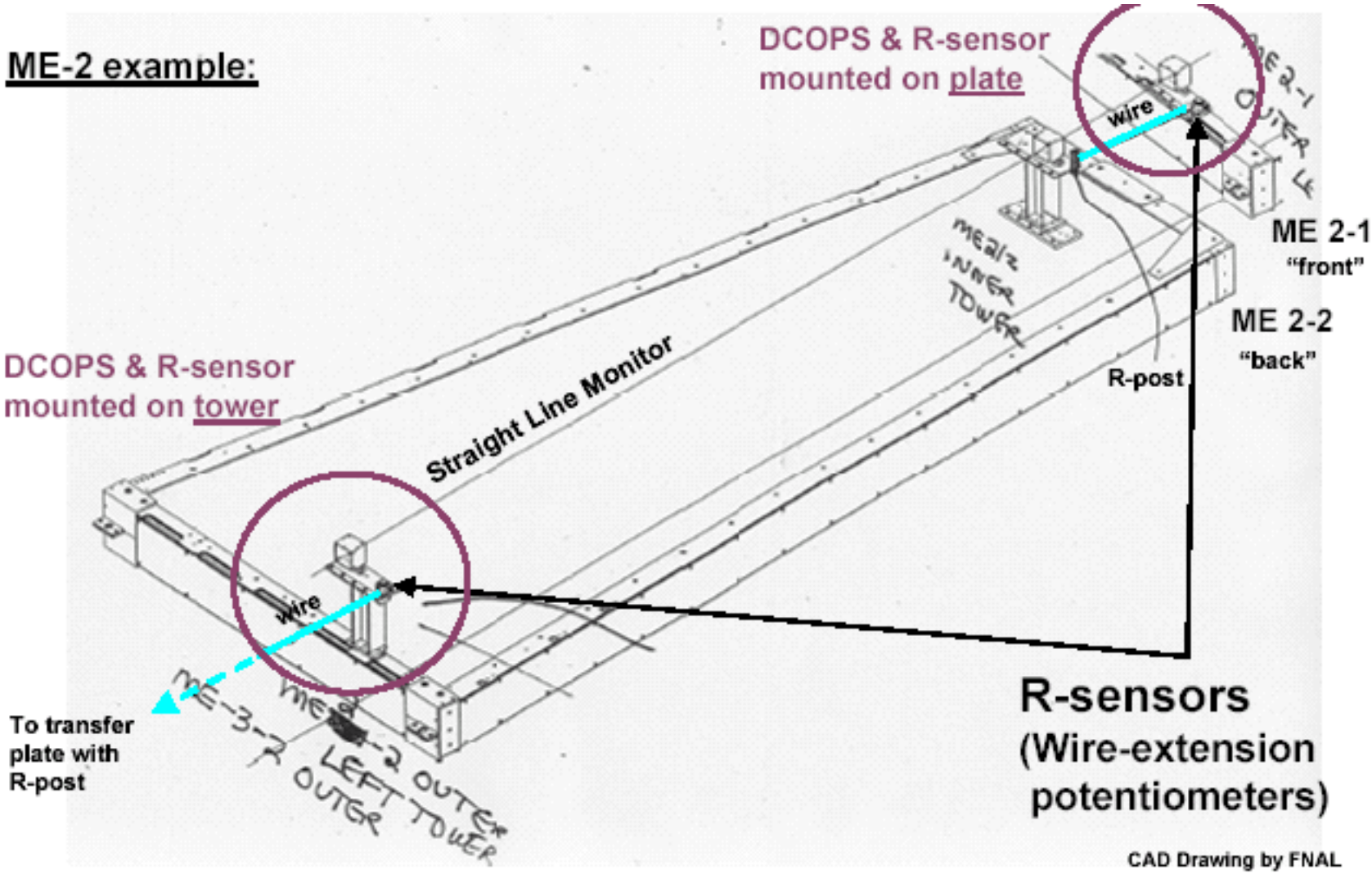


The CMS solenoid will be 13m long with an inner diameter of 6m – the largest superconducting solenoid ever made!

Installation of muon chambers on ME+2 endcap

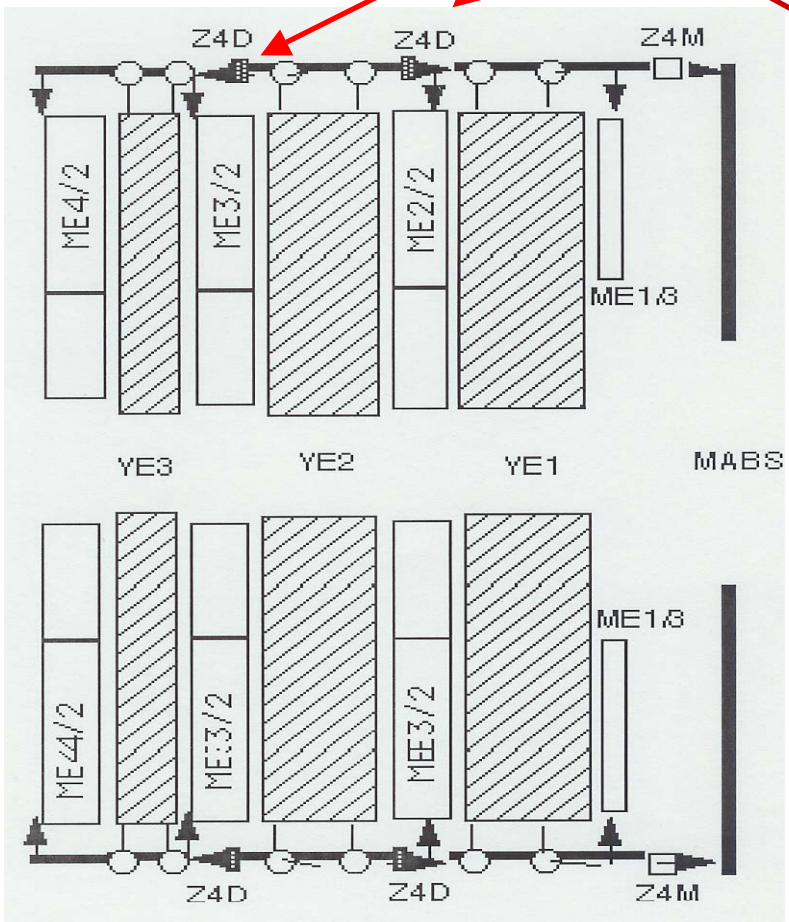


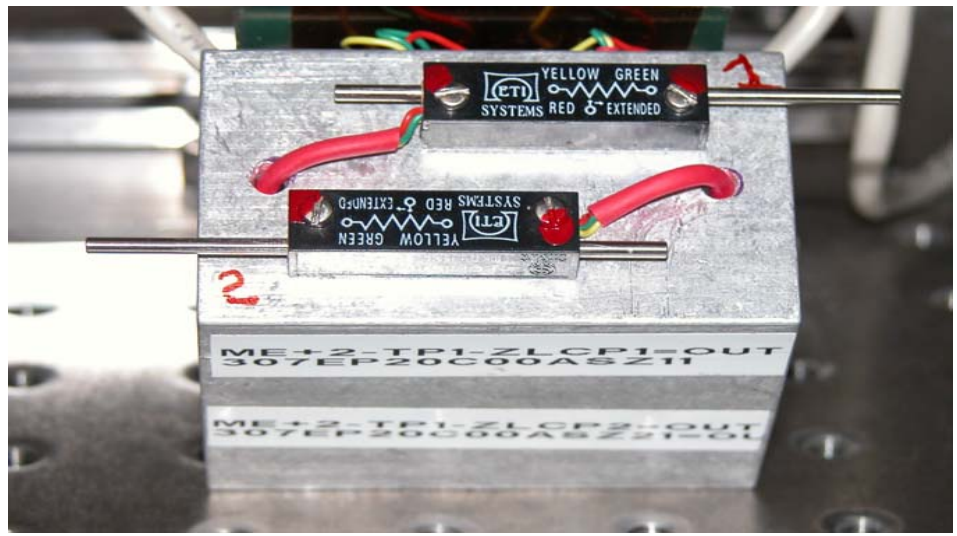
R – Sensor


ME-2 example:
DCOPS & R-sensor mounted on plate
wire
ME 2-1 "front"
ME 2-2 "back"
R-post
DCOPS & R-sensor mounted on tower
Straight Line Monitor
wire
To transfer plate with R-post
R-sensors (Wire-extension potentiometers)
CAD Drawing by FNAL

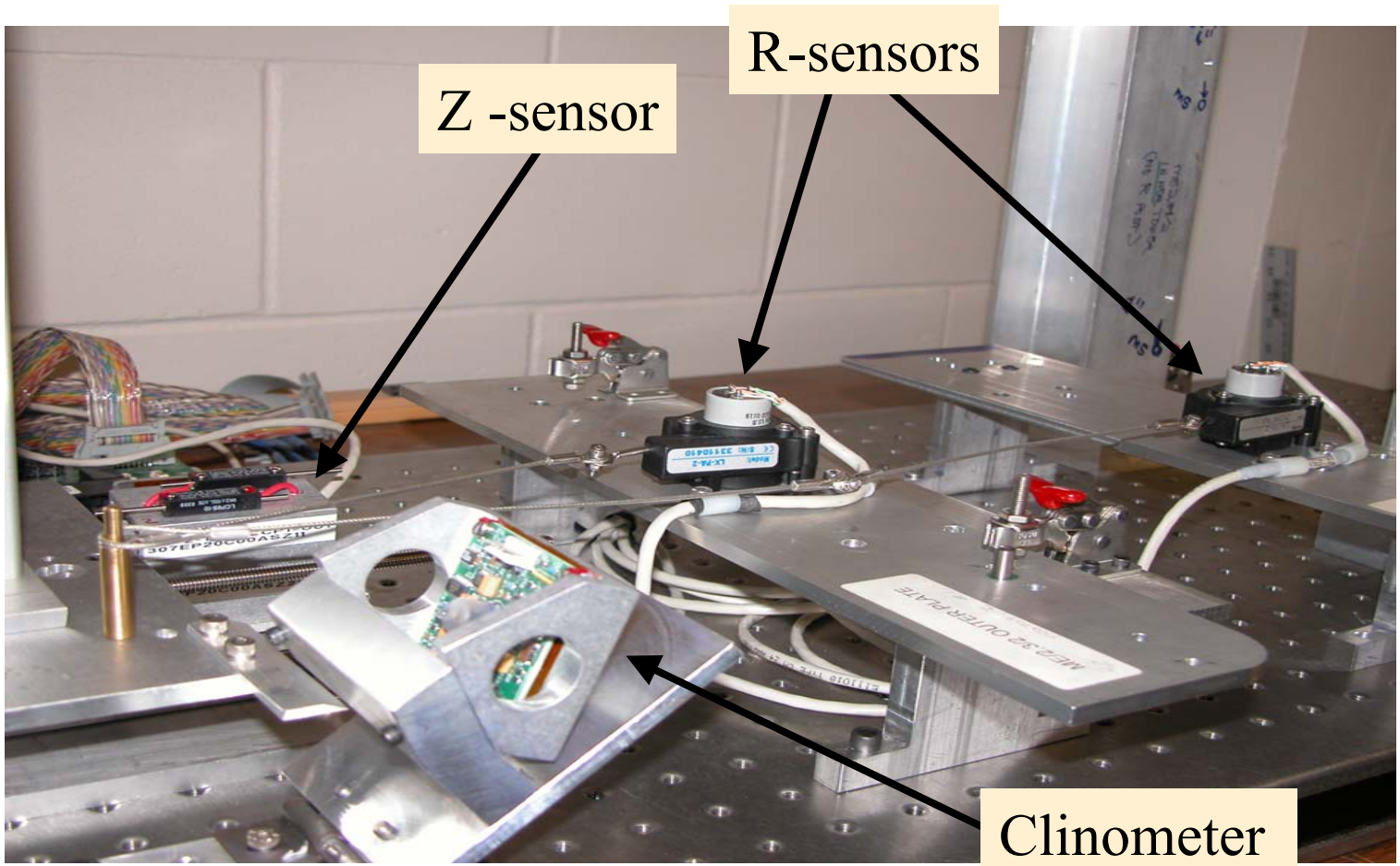
Z - Sensor

Linear motion potentiometer





Calibration of R , Z sensors and clinometers



Recent Activities

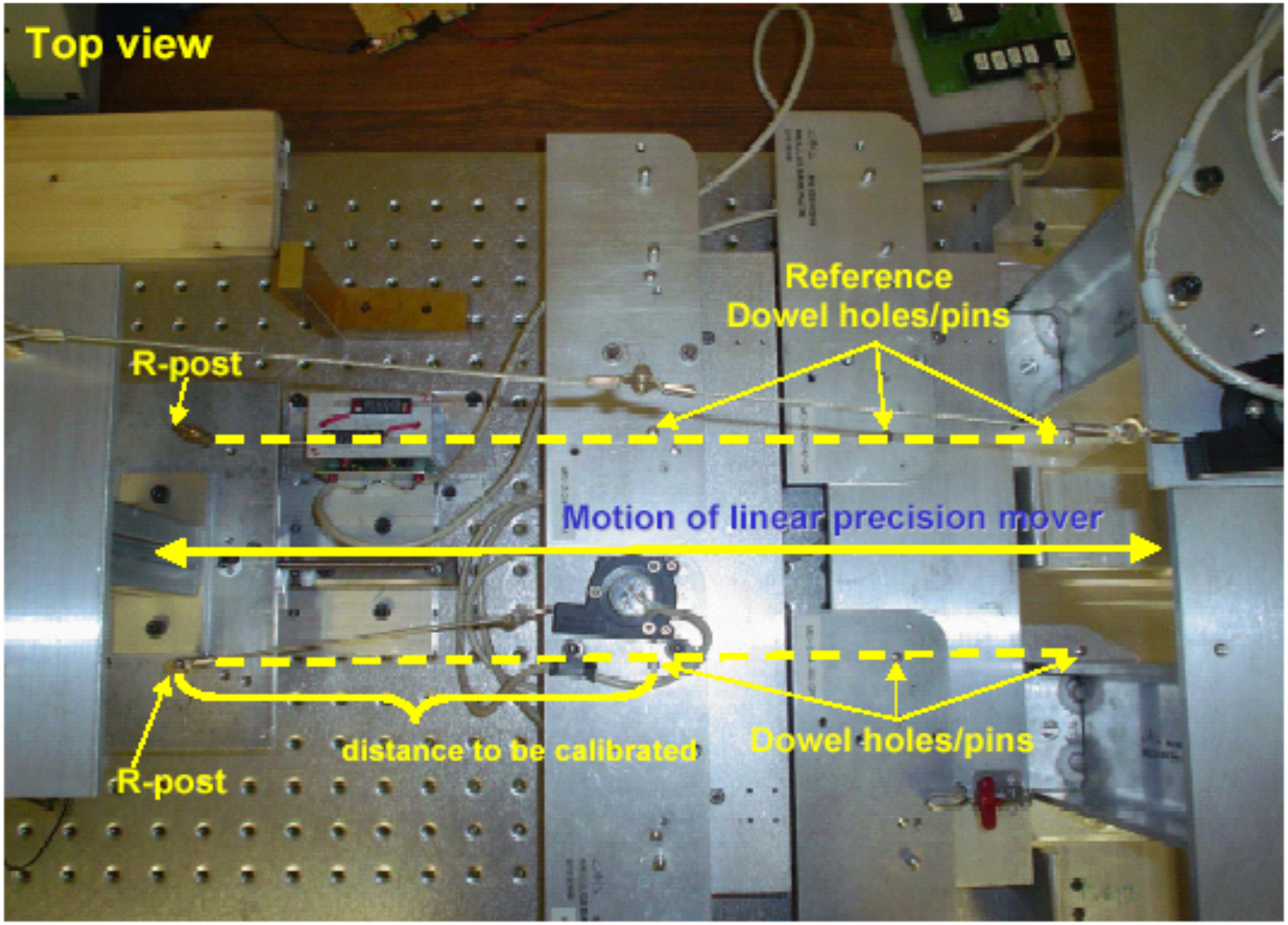
- Calibration Bench finished for R sensors, Z sensors, and Clinometers

- Understanding & reducing uncertainties:

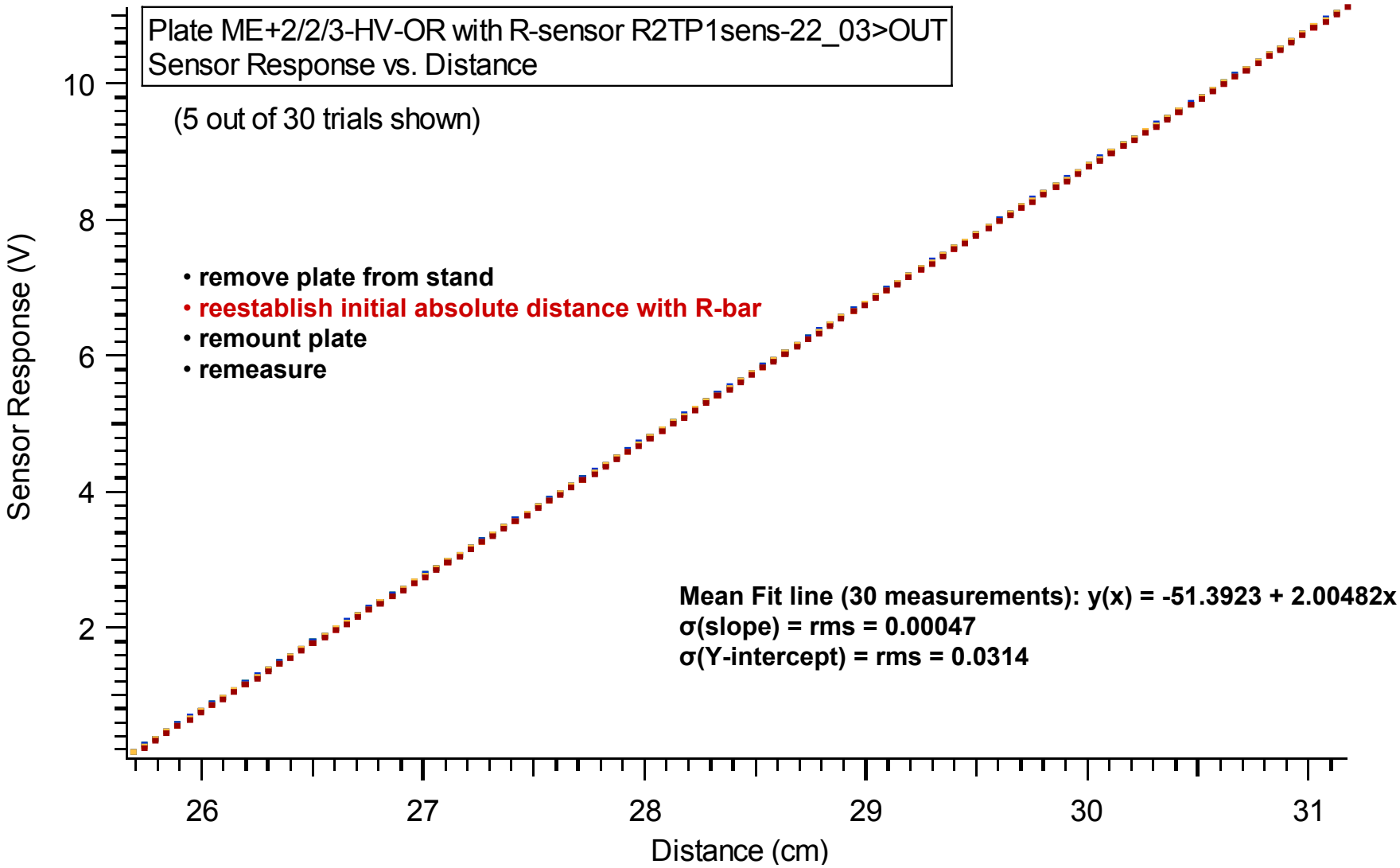
  -Reference bar accuracies
  -Mechanical Tolerance on dowel holes & pins
  -Mounting procedures

- Calibrating production sensors for ME+3

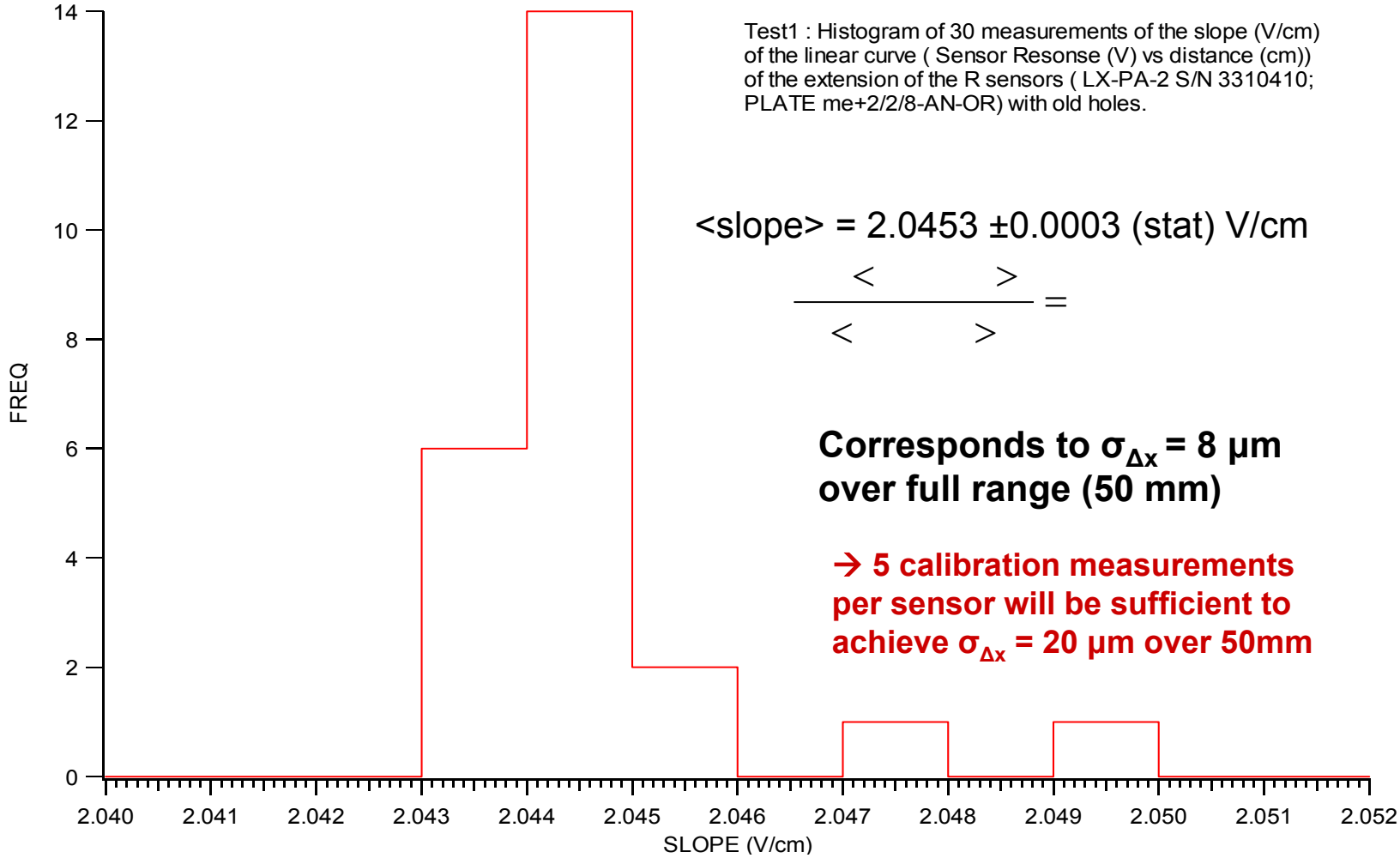
Line Up Reference points



Results for R-sensors:



Measuring relative changes in distances



Test1 : Histogram of 30 measurements of the slope (V/cm) of the linear curve (Sensor Resonse (V) vs distance (cm)) of the extension of the R sensors (LX-PA-2 S/N 3310410; PLATE me+2/2/8-AN-OR) with old holes.

<slope> = 2.0453 ±0.0003 (stat) V/cm

$$\frac{\langle \quad \rangle}{\langle \quad \rangle} =$$

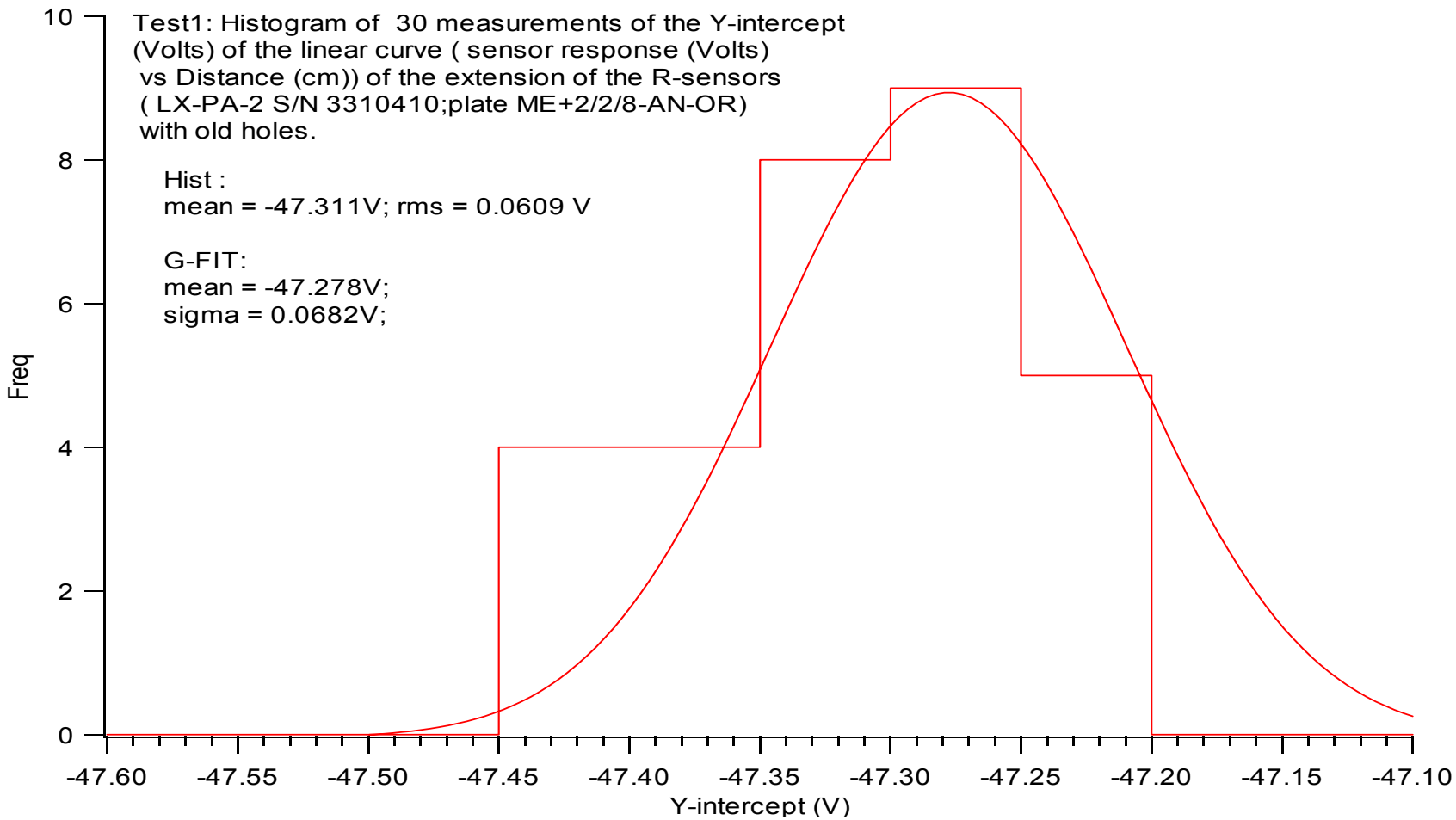
Corresponds to $\sigma_{\Delta x}$ = 8 µm over full range (50 mm)

→ 5 calibration measurements per sensor will be sufficient to achieve $\sigma_{\Delta x}$ = 20 µm over 50mm

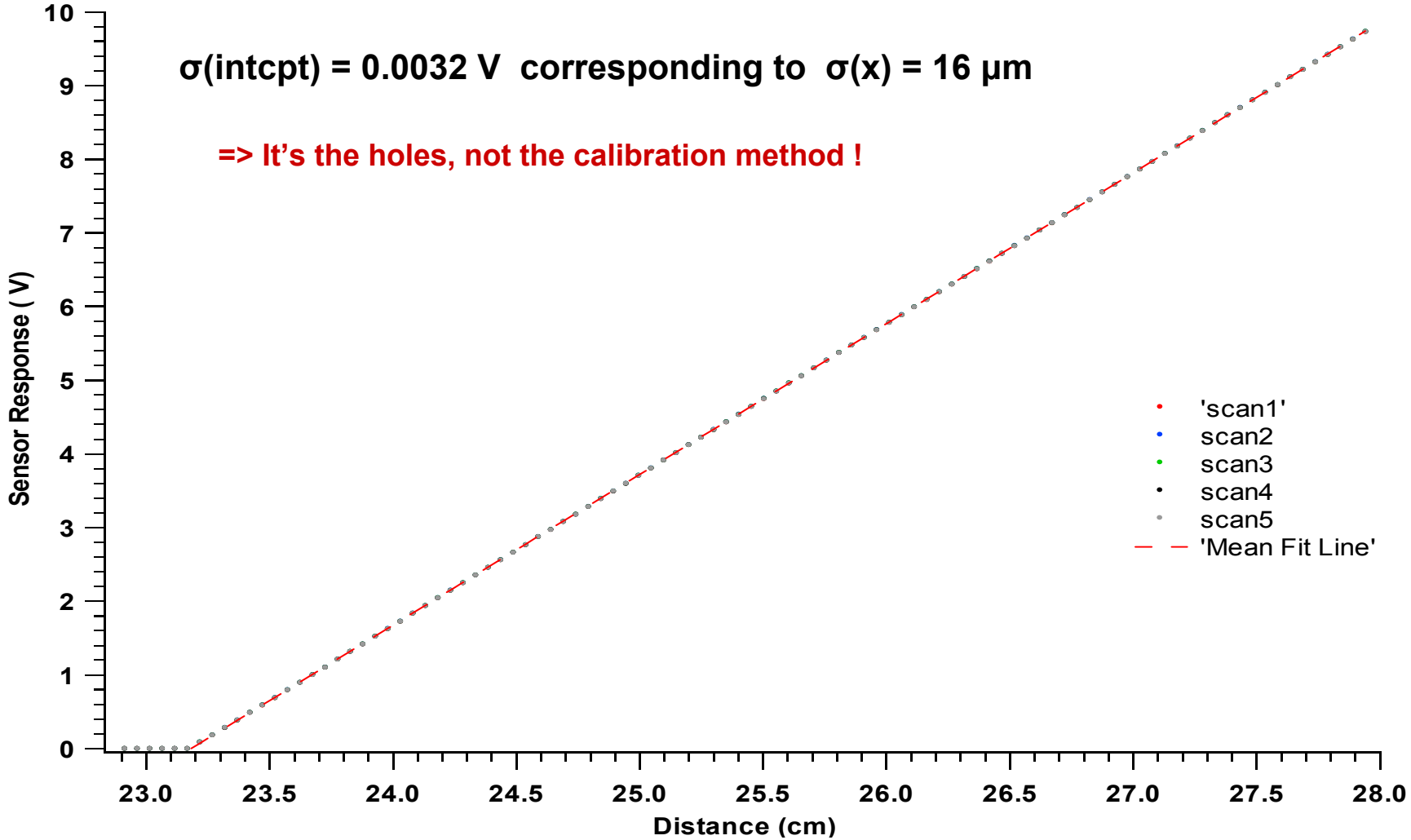
Measuring absolute distances : need new dowel holes.

$$\sigma(\text{intcpt}) = 0.061\,V$$

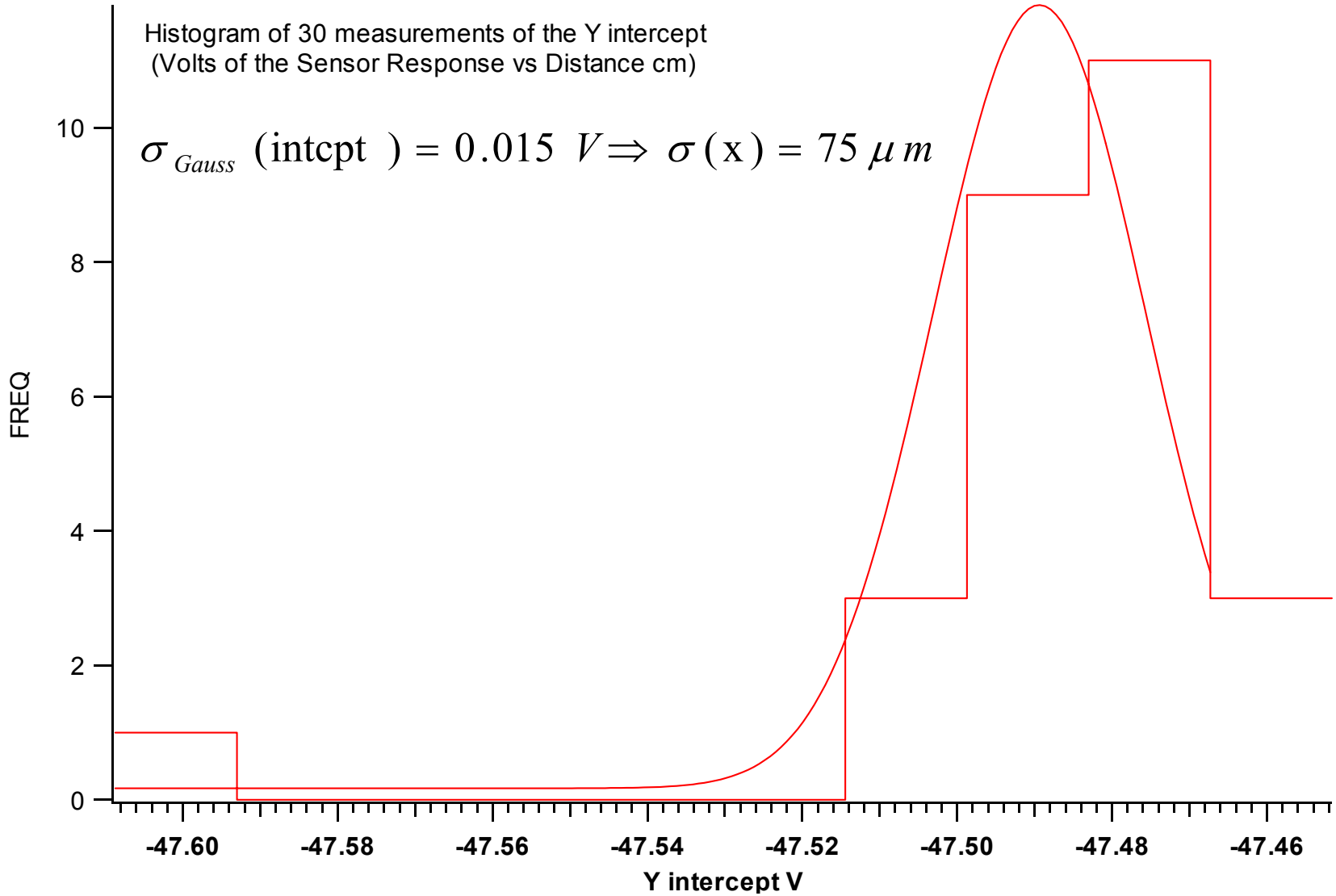
$$\rightarrow \sigma(\text{x}) = 300\,\mu m \Rightarrow \textit{problem with tolerance of dowel holes}$$



Checking the Calibration method : No dismounting and remounting of plates between measurement



Results with new holes



Current uncertainties in absolute R calibration

- Random uncertainties: (Dowel hole/pin tolerances, Initial absolute distance with reference bars) ± 75 μm

- Systematic uncertainties: (including calibration of stepper motor. Mechanical accuracy of reference bars. Non –parallel mover axis and line connecting R -post and dowel hole) ≤ ± 150 μm

Total ≤ ± 150 μm

Required: < ± 430 μm (from simulations)

Future Plan

- ME+2 : R and Z sensors ready for shipping and installation.

- Start mass calibration for R sensors and Z sensors, Inclinometers for ME+3,+4…

References

- CMS, The Muon Project Technical Design Report. The CMS collaboration, CERN/LHCC 97-32
- Dick Loveless, EMU meeting at Carnegie Mellon, 2003
- http://bulletin.cern.ch/